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Changes in the distribution of the "Yezo scallop" (Pecten yessoensis) and starfishes after mass planting of the scallop on the bottom of Vityaz Bay (Sea of Japan)

Yu.P. Volkov, A.A. Dadaev, V.S. Levin, and A.M. Murakhveri

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CHANGES IN THE DISTRIBUTION OF THE "YEZO SCALLOP" (PECTEN YESSOENSIS) AND STARFISHES AFTER MASS PLANTING OF THE SCALLOP ON THE BOTTOM OF VITYAZ BAY (SEA OF JAPAN)

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CHANGES IN THE DISTRIBUTION OF THE "YEZO SCALLOP" (PECTEN YESSOENSIS) AND STARFISHES AFTER MASS PLANTING OF THE SCALLOP ON THE BOTTOM OF VITYAZ BAY (SEA OF JAPAN)

By Yu. P. Volkov, A.A. Dadaev, V.S. Levin and A.M. Murakhveri

Scientific-experimental Base of Mariculture and the Laboratory of Chorology of the Institute of the Biology of the Sea of the Far Eastern Scientific Center of the USSR Academy of Sciences, Vladivostok 690022.

In Vityaz Bay in the Sea of Japan, for three months using light-diving gear, we studied the behaviour of Yezo scallop and starfish young after scallops were planted on the bottom. The population density of the scallop was considerably reduced a few days after planting. In addition to a dispersal of the scallop, a pronounced directed displacement of the bulk of molluscs was observed on two sections out of three. The distribution of the scallop and starfishes on the bottom is a dynamic system which changes in time and space. The area and general configuration of accumulations of the scallop and starfishes and the maxima of distribution density of these organisms as a rule coincide.

/37*

The Yezo scallop Pecten yessoensis is a most important object of the fishery in the Far Eastern seas of the Soviet Union. Its stocks have been reduced

*The numbers in the right-hand margin indicate the corresponding pages in the original. - Transl.

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considerably in recent years and artificial culture has been suggested. The central problem in the culture of the Yezo scallop is the low survival rate of young molluscs after planting on the bottom. One reason for this is its destruction by predatory marine organisms, particularly starfishes.

The information on the influence of starfishes on the abundance of the Yezo scallop in natural populations and in artificial culture is very contradictory (Kim, 1969a, b; Arima et al., 1971; Biryulina, 1972; Arima et al., 1972; Kalashnikov, 1980; Belogrudov, 1981). Analysis of the published data shows that assessments of the influence of starfishes on scallop populations are mainly based on indirect data, laboratory observations, comparison of the abundance of scallop and starfishes, the rations of different starfish species and their preferences for different mollusc species.

The aim our study was to observe the behaviour of the Yezo scallop after transplanting to the bottom in conditions close to real conditions at marine farms. To facilitate the study of the spatial structure and dynamics of change in population density of the scallops, they were planted with very high density. Permanent areas, suitable for scallop and with /38 natural populations of those starfishes most often present in bottom culture, and technically suited to prolonged detailed diving operations, are needed. Vityaz Bay in the Sea of Japa meets these requirements.

Material and methods

The studies were done from June to October 1980 using standard light-diving gear[1]. Diving was directly from the side of the supply ship or motor boat. A total of about 800h was spent under water.

After a preliminary diving survey to locate permanent areas, three were selected. Anchored buoys were set up at key points, and ropes

[1]Workers of the Laboratory of Tropical Seas and amateur divers from a number of cities took part in the work. The authors would like to express their thanks to all of them, and to the crew of Scientific-Research Vessel "Atna".

with 5m marks were layed. The main ropes were laid latitudinally and meridionally. Additional ropes were laid in the course of the work as the distribution of the scallop changed. Five 10X10m grids with 2X2m marking were set up for detailed counting on areas II and III. A 90X20m grid with 10X5m cells was laid out symmetrically to the main ropes in area I. The total length of permanent ropes laid is about 2600m.

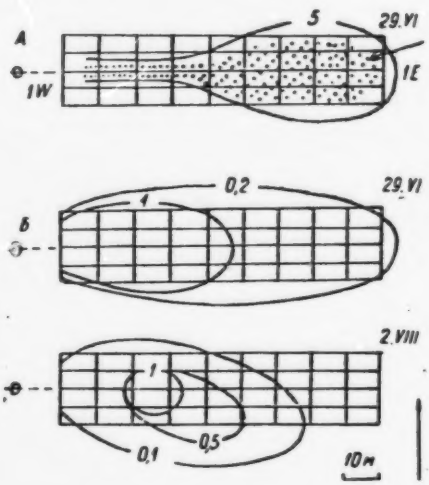

Fig. 1. Distribution of Pecten yessoensis (A) and Distolasterias nipon (B) on area I at different times, nm-2. Points - region of scallop planting; circle - situation of anchor chain of buoy with overgrowth.

About 500,000 Pecten yessoensis young were planted between June 13th and 17th. The scallop was collected at the age of 1 year at collectors in Minonosok Bay and were cultured until transplanting in suspension tanks at the plantations of the experimental marine base of the Special Experimental Design and Construction Office of the Ministry of Fisheries. The molluscs

were transported on the deck of a fisheries seiner in 30L tanks with perforated bottom and constant irrigation. The scallop was planted in area I in a strip along the 1W-1E rope, on area II on the 2Ts grid and in a strip perpendicular to the main rope in the region of point 2ATs, and in area III on grids 3Ts and 3ATs (Fig. 1-3). Planting was done: by scattering from the side of the moving ship in area I and at point 2ATs the scallop was planted by divers on the grids to create a uniform density of distribution. About 100,000 scallops were planted at each point. The average density after platning was about 1000 m^{-2}.

Four surveys were done after planting: June 26-30th, July 13-15, August 2-6th and 29-30th. Some counts were done in between. The scallop density was determined on 1X1m plots at 10m intervals along the length of the rope. Starfishes Asterias amurensis, Distolasterias nipon and Patiria pectinera were counted with a meter rule in a 10X1m strip along the rope. The actual abundance of organisms in each cell was counted in the grids. The results were recorded on an underwater chart. At the office, the data for each point in the area were grouped (Table 1) and plotted on a graph.

At all stages of the study, photographic survey of the bottom was done /39 along the ropes and in grid quadrats. Special cameras with Gidrorussar-8 or Mir-10 lenses and an attachement for photography in turbid water were used. Detachable scales, suitably marked, were attached to a rod in front of the camera to indicate the image scale and to mark the frame.

Results

The distribution of Pecten yessoensis and starfishes in the three /40 studied areas differed substantially.

Area I was situated in the corner of the bay at a depth of 18-19m. The bottom was almost smooth and silty. A survey done two weeks after planting showed

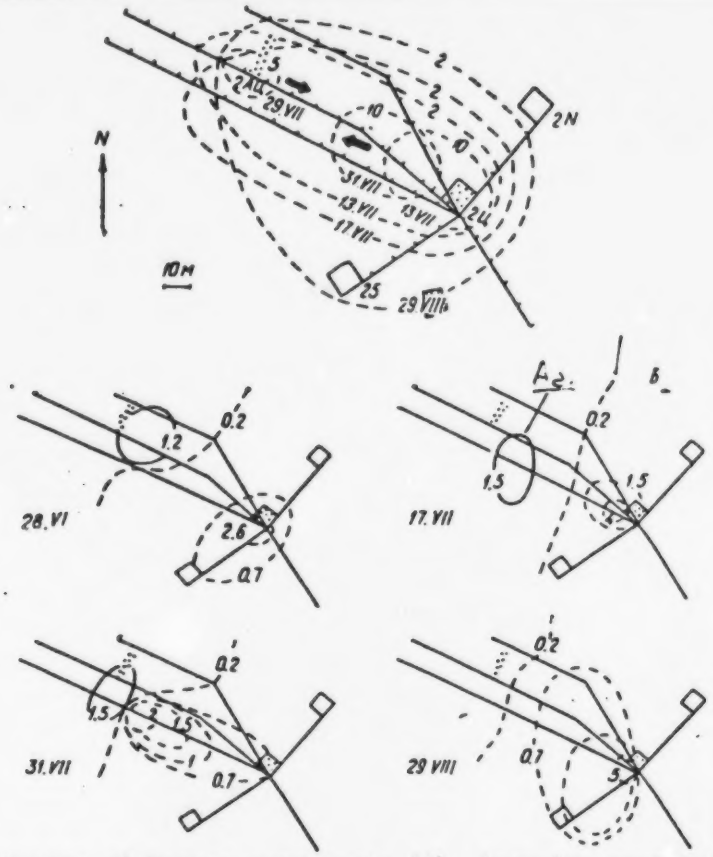

Fig. 2. Distribution of Pecten yessoensis (A), Asterias amurensis (B, solid line) and Distolasterias nipon (B, dashed line) on area II at different times, nm^{-2}.
The arrows show the main direction of movement of the scallop. The other symbols are the same as in Fig. 1.

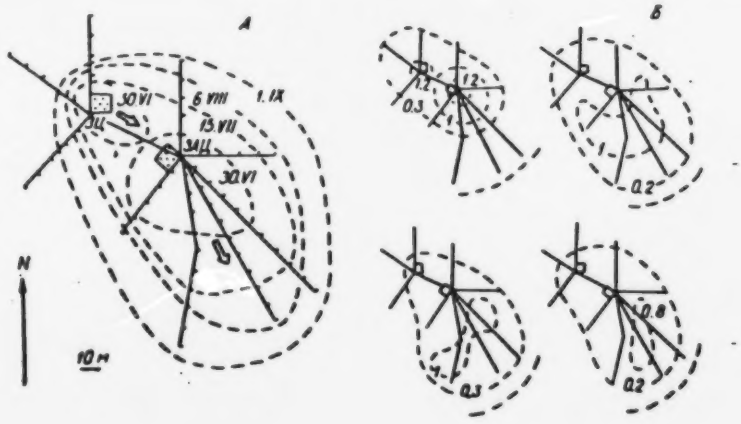

Fig. 3. Distribution of Pecten yessoensis (A, borders of field indicated) and Distolasterias nipon (B, nm^{-2}) in area III.
Other symbols the same as in Fig. 1.

TABLE 1

Changes in the distribution of Pecten yessoensis and starfishes along rope 3ATs-135^0 on area III based on the results of four quantitative surveys, nm^{-2}.

Species	Distance from point 3ATs, m.																			
	0 m				10 m				20 m				30 m				40 m			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Patinopecten yessoensis	—	1	18	3	—	1	12	4	—	18	13	2	—	2	18	2	—	2	18	2
Distolasterias nipon	0,1	—	—	—	0,9	0,5	0,4	0,2	0,9	5,0	0,2	0,2	0,9	0,8	0,5	0,2	0,6	0,2	0,3	0,4
Asterias amurensis	0	0	0	—	0,5	0	0	0	0,9	3,0	0	0,1	0,6	1,3	0,6	0,2	0,4	0,1	0,3	0,4
Patiria pectinifera	—	—	18,0	4,0	—	4,0	3,0	25,0	—	12,0	10,0	5,0	—	1,0	6,0	3,0	—	2,0	5,0	6,0

Note: The Roman numerals indicate the following survey dates: I - June 29th, II - July 15th III - August 6th, IV - August 30th.

TABLE 2

Distribution of Distolasterias nipon on grids in area II, nm^{-2}.

Grid	Survey date	Quadrat no.								
		1	5	7	9	13	17	19	21	25
2Ц	28.VI	3,7	4,2	2,2	2,5	0	0,2	0,7	3,5	3,0
	5.VII	3,0	—	—	8,2	3,2	3,5	0	—	6,5
2N	28.VI	0,5	0	0,5	0,2	0,2	0	0,2	0,5	1,0

that the borders of the scallop field had changed little from its initial configuration (Fig. 1). The molluscs moved very little. At the places of the densest accumulations, they were distributed in a single layer occupying up to 50% of the bottom area. A slight increase (by 10-15m) in the area of the field was observed later. The boundaries of the field were very clear, single specimens being found outside the field only in August. The scallop lay flat, the upper valves covered with silt. Mobile individuals free of silt made up 1-5% of the total number.

There were no large starfishes on the area before planting of scallops because of the silty bottom and the low number of food organisms. A mooring buoy with a thick overgrowth on its anchor chain is situated at the western end of tl area (Brykov et al., 1980). Bunches of oysters and mussels which fall to the bottom attract numerous D. nipon to the base of the chain. The abundance of starfishes on the area did not increase for several days. After a week, the density of D. nipon at the center of the scallop accumulation was about 0.5, and by August 2nd, it had increased to $1m^{-2}$. The configuration of fields and the centers of density of scallop and starfish populations coincided. Observations showed that the grid ropes helped the starfishes to move along the loose substrate, thus facilitating their colonization of the area.

Area II was situated at the southern shore of the bay. Its depth increases from 20 (southeast) to 33m (northwest). In the shallow part of the area, the bottom is sandy and contains shell detritus and whole and slightly separated mollusc valves. On the slope, the bottom is a mixture of shells and shell detritus and is a washed-out coquina beach. At the lower part of the area, the shell is buried under fine-grained sand, which gradually becomes pure silt deposits.

A movement of indiyidual scallops began immediately after planting, leading on the one hand to dispersal and on the other to a directed displacement of the entire field. It was on this area that the pattern of distribution of the scallop was most complex (Fig. 2). The scallop began to move from the planting point 2Ts mainly towards greater depths. Twelve days after planting, the density of live scallops at a distance of 40 m from point 2Ts was 5 and the number of dead valves up to 25 nm^{-2}. The scallops moved in the opposite direction from planting point 2ATs, that is, up the bottom slope. At the time of the July 13th survey, both scallop fields had combined and the boundary of the whole field took on (and later kept) the shape of an ellipse, whose major axis passed through the planting points. The speed of redistribution of the scallop, /41 despite the seeming chaos in the movement of individual molluscs, was rather fast. Two weeks after planting, the density at the center of grid 2Ts had fallen from 1000 to 380, and to 150-30 nm^{-2} at the margins.

P. pectinfera was noted on the area before the scallops were planted (2-10 nm^{-2}). The distribution of D. nipon and A. amurensis on this area was somewhat unusual. The first species was noted predominantly in the relatively shallow part of the area, the latter species in the deep, although the opposite picture is more often observed. There was a considerable redistribution of the starfishes on the area immediately after planting of the scallops. Two weeks after planting, D. nipon reached its maximal density of 4.7 m^{-2}, which coincided territorially with the densest scallop accumulations. Distolaria maintained its background density (0.2 - 0.7 m^{-2}) on the control grid 2N. Following the displacement of the area of maximal scallop density towards greater depths, D. nipon began to move in the same direction, but with some delay. The extended "front" of the movement of the starfishes was clearly discernible. However, despite the noticeable change in the configuration of the field of

of starfishes, a large portion of them did not move from the point of the original accumulation - in the control grid 2Ts, three weeks after planting, the density of Distolasteria reached 6.5 m^{-2} in some parts (Table 2).

The abundance of starfishes also increased sharply in the lower planting area, the density of A. amurensis reaching 1.2 - 1.5 m^{-2}. Following the displacement of the planted scallops to the east, the strafishes moved in the same direction, but this displacement was less pronounced in accordance with the relatively small migration of the scallop from the lower planting point.

The survey of August 29th showed that both fields of starfishes which were moving towards each other following the scallop accumulations, had joined up. The maximum density of the combined field was situated near the upper scallop planting field. Note that point 2ATs is the only one of the five planting points at which the original "background" density of starfishes had been restored by the time of the fourth survey.

Area III was situated at the northern shore of the bay at depths /42 of 10-27m. The distribution of soils here is similar to that on area II - sand with coquina in the shallows, followed by a deposit of mollusc valves, exposed on the slope then covered by silty sand, gradually becoming silt,

The behavior of the molluscs was the same at both planting points - the scallop spread in all directions, but predominantly to the southeast, in the direction of increasing depth (Fig. 3). Both fields joined up after a month, and the bulk of the scallops in the new field moved in their original direction. At the upper planting point 3Ts, the scallop was found singly, and the center of maximal density (50 m^{-2}) was situated to the southeast of point 3ATs. The density of the scallop population decreased as the area of the field increased - a maximum density of 18 m^{-2} was noted at the beginning of August, 12 m^{-2} at the end (average densities of 1-3 m^{-2}).

Following the planting of the scallops, there was a rapid redistribution of the starfishes in the area, especially of D. nipon, which dominated in biomass and abundance. The highest density of this species (up to 12 m^{-2}) at first coincided with the scallop planting sites. A zone of almost complete absence of starfishes was observed around these areas. Further surveys revealed that as the scallops were redistributed in the area, both maxima of D. nipon density merged and began to shift to the southeast following the movement of the scallops. The densest accumulations of scallops and starfishes coincided territorially. The field of maximal density of starfishes decreased in area with the passage of time; consequently, the total abundance of D. nipon on the area, which had increased sharply after planting of the scallops, declined as the scallops dispersed. The distribution of A. amurensis showed a similar pattern of change, but because of the considerably smaller abundance of this species, the changes were less marked. The presence of the scallops also affected the distribution of P. pectinfera which normally does not feed on Pecten yessoensis (Tables 3; Fig. 4, see Inserts III, IV).

Discussion

The underwater observations and the quantitative surveys showed that the planting of scallops on the bottom is followed by a redistribution leading to a decrease in the density of the scallop population. On some areas, the density decreased from several hundred to several specimens per m^2 within a few days. In addition to this dispersion, an intensive ordered migration of the bulk of the scallops was observed on two of the three areas. In area II, the scallops moved towards each other from the two planting points. It would be of great scientific and practical interest to explain this behavior, which has not previously been observed.

A possible explanation of this directed movement of the scallop may be an attack by predatory starfishes. Our data do not support this hypothesis

and suggest that some other factors are more important. On area I, which has a very uniform bottom, there was no directed movement of the scallops, despite the fact that a clearly directed "attack" of starfishes from the direction of the mooring buoy anchor chain with overgrowth was in fact observed in this area. In areas II and III, the distribution of the studied starfish and scallop species coincided in both space and time. The starfishes gathered at the scallop accumulations from various directions at approximately the same rate, and yet the directed movement of the scallops here was still very pronounced.

TABLE 3

Distribution of Distolasterias nipon (above the line) and Patiria pectinifera (below) on area III, nm^{-2}. /43

Grid	Survey date	Quadrat no. 1	5	7	9	13	17	19	21	25
3Ш	26.VI	2,2	2,0	9,5	10,0	2,5	4,2	8,5	4,5	3,0
		0	0	0,5	0	0,5	0	0,5	0	0,5
	5.VIII	2,0	4,0	4,5	7,5	5,8	8,2	10,0	6,8	4,2
		0,2	0,7	0,2	0,2	0,2	1,0	0,7	0,2	0,2
	1.IX	1,8	3,0	3,0	3,5	2,2	4,2	10,0	4,2	3,2
3АШ	26.VI	4,2	1,5	1,0	5,7	13,0	11,0	4,2	8,2	4,7
		0,2	0,5	0,5	0	0,2	0	0	0	0
	5.VIII	12,0	18,0	12,0	12,0	12,0	12,0	18,0	12,0	12,0
		0,2	0	0,2	0,2	0	0	0,7	—	0
	1.IX	3,8	3,2	11,0	5,5	4,0	6,2	4,5		5,2

In our opinion, starfishes play an indirect role in the directed /43 movement of young scallops by stimulating the swimming activity of the molluscs. The most likely explanation, in our opinion, of the directed movement of the scallops lies in the fact that in the course of their chaotic swimming movements, the individual scallops move in the direction of the bottom gradient for strictly mechanical reasons. In fact, the main directions of the scallop movements in areas II and III coincided with the bottom gradient. However, this "migration" of the scallop, if it is indeed the cause of its movement, is at least not the only one. It can in no way explain the movement of the scallop from point 2ATs in area II up the bottom slope (even though the slope was very gentle). This movement can also not be explained by bottom features, since very careful observations did not reveal any marked gradient in bottom features or distribution of the bottom population which would prevent the movement of the molluscs.

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